P. **LOWER PACK RIVER**

(tributary to north Pend Oreille Lake)

Waterbody Type:	river
Ecoregion:	Northern Rockies
Designated Uses:	Domestic and agricultural water supply, cold water biota, salmonid spawning, and primary and secondary contact recreation.
Size of Waterbody:	approx. 40 miles long
Size of Watershed:	101,207 acres

Summary: The Pack River was listed for nutrient, sediment, dissolved oxygen, habitat alterations, pathogens, and pesticide pollution. The conclusions of this problem assessment is that the Pack River is water quality limited due to excess sediment and nutrients. Monitoring data indicate that dissolved oxygen, pesticides and pathogens concentrations do not violate Idaho Water Quality Standards. EPA requests that additional pathogen data be collected in 2001 before a listing decision is made. Target load for sediment is **15,635** tons/yr (a reduction of 45,465.6 tons/yr). Target loads for nutrients are: **5,307** kg/yr total phosphorus (a reduction of 15,293 kg/yr) and **45,815** kg/yr total nitrogen (a reduction of 51,985 kg/yr).

1. Physical and Biological Characteristics

The Pack River is the second largest tributary to Lake Pend Oreille, and is in turn fed by a number of significant tributary watersheds. The watershed encompasses 101,207 acres of Bonner and Boundary counties in north central Idaho, and drains in to the northern tip of Lake Pend Oreille between the communities of Hope and Sandpoint, Idaho.

Climate. The climate of the Pack River watershed is middle latitude continental (Corsi 1998). Climatic conditions are influenced by both continental and marine weather patterns. Frequent winter storms pass over the area from November through March. Summer storms, however, generally pass farther north resulting in a relatively dry climate.

Hydrology. The Pack River and its tributaries often experience one or more run-off events. Mid-winter rain-on-snow events can result in rapid snowmelt, and in some years the peak flow from tributary watersheds occurs during these events. Due to high precipitation results, location in relation to the lake and prevailing winds, tributaries draining the Cabinet Mountains are particularly susceptible to rain-on-snow events (Corsi 1998).

Geology. The geologic parent materials located in the Pend Oreille Lake watershed are the result of millions of years of sedimentation, metamorphosis, uplift, and intrusion. Streams on the northeast side of the watershed (in the Cabinet mountains) are primarily within the Belt Series bedrock type, and streams draining the Selkirk Mountains are largely within the Kaniksu batholith (granitic bedrock type) (Savage 1965).

The Belt Series are metamorphic sedimentary deposits comprised partially by the Cabinet Mountains. Sediments of clay, silt, and sand settled out of the brackish waters of shallow Precambrian seas, metamorphosed, and began to fold and fault. The metamorphosed rocks include argillite, siltite, quartzite, and dolomite.

An igneous intrusive, known as the Kaniksu Batholith, comprises the Selkirk Mountains which make-up the northwest section of the drainage. This intrusion is composed of granodiorites and quartz monzonite.

Soils. Soils found in the watershed are mostly derived from the erosion of Precambrian metasediments and granitic batholith, volcanic deposition, glacial outwash, glacio-lacustrine sediments, and alluvium. Most land types have 10 inches or more of surface soils composed of Mt. Mazama volcanic ash, which has very high water infiltration rates. (Hoelscher 1993).

The area adjacent to the Pack River Mainstem is dominated by two soil types: Pend Oreille Rock outcrop-Treble unit and Mission-Cabinet-Odenson unit. Both are poorly suited to roads, dwellings, and recreational development. The Pend Oreille-Rock outcrop-Treble unit is poorly suited because of steep slopes (5-65%), erosion hazards, and areas of rock outcrop. The Mission-Cabinet-Odenson unit is equally poorly suited because of a seasonal perched water table, very slow permeability, and a hazard of frost heaving (Hoelscher 1993).

Watersheds in the Cabinet Mountains tend to be more prone to rapid run-off events due to the effects of scour by glacial advances. These glacial events resulted in highly dissected watersheds (i.e. high density of streams), shallow soils, and subsoil compaction of glacial tills.

The Pack River basin has more glacial fluvial deposits than any other basin in the Pend Oreille watershed, and the underlying geology is largely granitic in origin. As a result sand sized sediment is the primary material that is eroded and transported in streams. Fish habitat features are less likely to change from channel adjustments, but the river is prone to high levels of fine sediment which occur where hill side or stream bank erosion rates, and in-channel deposition, is high.

Loss of riparian vegetation and associated root masses due to fire, salvage, timber harvesting, livestock grazing or clearing reduces bank stability and results in delivery of fine sediment to the stream channel.

Land Ownership. The Pack River basin supports diverse land uses and contains lands under private, state, and federal ownership. Land ownership for the entire watershed (101,207 acres) can be broken down to the following percentages: US Forest Service - 55.0%; Private lands - 36.0%; State lands - 6.6%; and Bureau of Land Management - 2.4%. Primary ownership of the headwaters is federal (Forest Service), while the lower reaches are under private ownership.

Land Use. Land uses of the Lower Pack River, as identified by the IDHW-DEQ (1993) are reported out of a total of 106,993 acres (43,299 hectares) as follows: Forest - 87524 acres (35,420 hectares) (81.8% of total); Agriculture - 5266 acres (2,131 hect.) (4.9%); Livestock - 6365 acres (2,576 hect.) (6.0%); Timber/Grazing - 1,223 (2.8); Mining - 15 acres (6 hect.); Transportation - 694 acres (281 hect.) (0.6%); Residential - 3311 acres (1,340 hect.) (3.1%); Commercial - 12 acres (5 hect.); Industrial - 74 acres (30 hect.) (0.1%); Public parks and recreation - 361 acres (146 hect.) (0.3%); Surface water - 356 acres (144 hect.) (0.3%). These uses, coupled with the Sundance fire in 1967, have influenced fish habitat conditions and water quality in the Pack River.

2. Pollutant Source Inventory

Point Source Discharges

There are no permitted point source discharges to the Pack River or its tributaries.

Nonpoint Source Discharges

There were five primary nonpoint sources of pollution identified by the Panhandle Bull Trout Technical Advisory Team as limiting water quality in the Pack River Mainstem watershed (Corsi et al. 1998). These sources are identified and described as follows:

Urbanization - Significant floodplain development, increased urban run-off, stream riparian zone clearing, and stream channel alterations are all factors associated with urban development which currently limit water quality and beneficial uses in the watershed.

Roads - Pack River has an extensive road system on private, state and federal lands. Because of the sandy soils, fine sediment is readily transported from roads to stream channels. Three railroads (Burlington Northern Santa Fe, Union Pacific, and Montana Rail Link) and two highways (US 95 and Idaho 200) cross lower Pack river, creating a risk from toxic spills.

Wildfire - The Sundance Fire, which occurred in 1967, was the last major forest fire in the Pack River watershed. It burned nearly 55,000 acres of mature and second growth timber in the Selkirk Mountains, Pack river and Roman Nose Creek drainages (USDA 1992). The fire burned a large portion of the riparian areas in the upper Pack River drainage. Legacy effects of the Sundance Fire are still visible in the Pack River system.

Agriculture/Livestock Grazing - Use of land for agriculture practices has been ongoing for many years in the Pack River drainage. Grazing occurs in the lower 2/3 of the watershed, and much of the Pack River is considered open range. Crop production occurs in the watershed from below the Highway 95 bridge to the inlet at Lake Pend Oreille. Large cedar trees and riparian vegetation was removed years ago. Impacts to the stream channel in lower reaches have occurred over a long period of time and continue to be a factor in the decreasing habitat condition today.

Timber Harvest - Most timber harvest since 1967 has taken place on private and federal lands in the lower 2/3 of the watershed that were not burned by the Sundance Fire. Salvage logging occurred in burned areas, possibly reducing large woody debris recruitment to stream channels. Harvest is currently taking place in areas missed by the fire where merchantable timber was left (Sundance Missed Timber Sale). Timber harvest on private lands is also occurring.

2.a. Summary of Past and Present Pollution Control Efforts

As a result of citizen concerns about increased aquatic weed and algae growth in the Clark Fork River, Pend Oreille Lake and Pend Oreille River, the U.S. Congress added language to the 1987 Clean Water Act Amendments (P.L.100-4, Feb.4, 1987) that directed EPA to study the sources of nutrient pollution in the basin. A comprehensive three year study led to the development of the Clark Fork-Pend Oreille Basin Water Quality Study, A Summary of Findings and a Management Plan (EPA 1993), designed to protect and restore water quality in the watersheds from nutrient pollution. The Tri-State Implementation Council was established in October 1993, to oversee implementation of the Plan. The Council's primary goals and accomplishments are directed towards protection of Pend Oreille Lake and Clark Fork River. Examples of accomplishments which work to protect water quality in the Pack River include:

1. A basin wide phosphate detergent ban.
2. Offered educators tours of the watershed.
3. Established and currently maintaining a water quality monitoring network throughout the basin.
4. Assisted Bonner County in developing an effective stormwater and erosion control ordinance.

Washington Water Power, as part of their relicensing process for the Noxon and Cabinet Gorge hydro-power projects, agreed to certain protection, mitigation, and enhancement measures. Many of these projects will benefit the water quality of the Pack River. Stream improvement projects, fish passage projects, habitat restoration, bank stabilization and similar types of activities should benefit both fish habitat and water quality. Funding over the next 45 years should result in a substantial number of improvement projects being achieved.

In 1993, Bonner County adopted a stormwater ordinance which, if enforced, would provide for adequate protection of the lake and its tributaries from sedimentation as a result of various land disturbing activities.

The Idaho Forest Practices Act has recently added the Cumulative Watershed Effects Process for Idaho (Idaho Cumulative Effects Task Force 1995) added to it as a tool to evaluate problem watersheds. This process enables the forest practices advisor to recommend additional protection measures to address cumulative effects of timber harvest. In areas which have been heavily roaded or are prone to unstable geology, site specific Best Management Practices, developed from this process should significantly reduce sedimentation of streams.

In addition, Pend Oreille Lake has been designated a Special Resource Water (IDAPA 16.01.02.056). As a tributary to a Special Resource Water, the Pack River cannot have a point source discharge which will result in a reduction of ambient water quality of the lake.

In June 1995, the US Fish and Wildlife Service status review found listing bull trout (*Salvelinus confluentus*) as threatened or endangered was warranted under the Endangered Species Act. On July 1, 1996, Governor Phil Batt and the State of Idaho issued a Bull Trout Conservation Plan outlining proactive measures to be taken by the state to restore bull trout populations in Idaho. The Plan utilizes the Basin Advisory Group and Watershed Advisory Group framework, initially developed for dealing with 303(d) water quality listed streams under Idaho Code (39-3601). The plan would provide for local development of watershed specific plans to maintain and/or increase bull trout populations and meet the needs of the surrounding communities in Idaho. While the state will not mandate how local communities protect the species, it will insist on meeting the goal of protecting and maintaining the species (Corsi 1998).

The *Lake Pend Oreille Key Watershed Bull Trout Problem Assessment,* completed in 1998, addresses the Pack River as a tributary to Lake Pend Oreille relative to bull trout populations. The mainstem Pack River was designated a key migratory corridor for bull trout between Lake Pend Oreille and important spawning and rearing areas in the upper reaches of the river and its significant tributaries (Corsi 1998).

3. Water Quality Concerns and Status

In 1996 the mainstem Pack River (Hwy. 95 to Pend Oreille Lake) was added to the 303(d) list as water quality impaired, due to excess nutrients, sediments, low dissolved oxygen gas, excessive habitat alterations, pathogens, and pesticides.

The Pack River has designated uses of domestic and agricultural water supply, cold water biota, salmonid spawning, and primary and secondary contact recreation. Of these beneficial uses, only industrial water supply, wildlife habitat, and aesthetics were identified as having full support status according to 1996 Waterbody Assessment Guidance analysis. This segment was also listed in the 1994 305(b) report as a Stream Segment of Concern for the same pollutants mentioned in the 1996 303(d) list.

Fine sediment, lack of large woody debris to create pools and cover, and elevated temperatures resulting from loss of shade (habitat alterations) are believed to be significant limiting factors of bull trout production in the Pack River. Three railroads and two highways cross lower Pack River in the migration corridor, creating a risk to migrating bull trout from toxic spills.

The Pack River has been found to contribute the highest ratio of nutrients per unit of land of any watershed in the Pend Oreille Basin. This is likely a result of the high ratio of sediment that is produced within the watershed due to the geology of the watershed and the heavy land use in the lower reaches of the Pack River (Hoelscher, et al. 1993).

There is also some evidence that the Pack River is nitrogen limited at certain times of the year. The ratio of nitrogen to phosphorus found in the Pack River in 1989 was approximately 5:1. A total nitrogen to total phosphorus ratio in lakes greater than 15:1 indicates phosphorus limitation. A lower ratio is typically found in eutrophic lakes with frequent algae blooms. Specific information on nutrient ratios for rivers was not found.

The cause for the listing of pesticides as a pollutant may have been due to the construction of a golf course at the mouth of the Pack River. Other reasons for the listing may have been pesticides used for the road side spraying of noxious weeds, fungicide use in a tree nursery, or lawn care products.

3.a. Applicable Water Quality Standards

Designated beneficial uses of the Pack River include: agricultural water supply, domestic water supply, primary and secondary contact recreation, cold water biota, and salmonid spawning.

Uses reported to be currently impaired or not fully supported are: agricultural and domestic water supply due to pathogens and pesticides; primary and secondary contact recreation due to excess nutrients; cold water biota due to excessive sediment, low dissolved oxygen and pesticides; and salmonid spawning due to sediment and low levels of dissolved oxygen.

The Pack River has been found to be the second greatest source of nutrients to Pend Oreille Lake. The state water quality standards under IDAPA 16.01.02.200.06 states, "Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses. Identifying and controlling nutrient sources in the Pack River watershed has been proposed as a management alternative for reducing nearshore eutrophication in Pend Oreille Lake (Hoelscher, et al. 1993).

Pesticides are limited in surface waters by either the National Toxics Rule, adopted (with changes) to the Idaho Standards in 1997 or the general surface water quality criteria (IDAPA 16.01.02.200.02) which requires that surface waters shall be free from toxic substances which impair beneficial uses.

Pathogens are limited to fecal coliform bacteria organisms of no more than 500/100 ml at any time; and 200/100 ml in more than 10% of samples taken over a 30 day period; and a geometric mean of 50/100 ml based on a minimum of five samples taken over a 30 day period.

The Idaho Water Quality Standards narrative criteria (IDAPA16.01.02.200) states that sediment shall not exceed, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Such impairment is determined through water quality monitoring.

Dissolved oxygen in the Pack River must exceed 5 mg/l at all times.

3.b. Summary and Analysis of Existing Water Quality Data.

The Pack River was evaluated at several sites for beneficial use status as part of *The 1992 Idaho Water Quality Status Report.* In this report, most upstream sites were evaluated only for cold water biota and salmonid spawning beneficial uses, which were rated as partially supported or supported but threatened. The reach between Gold Creek and Rapid Lightning Creek (the furthest downstream reach evaluated) included a fish tissue analysis, which indicated that high amounts of pesticides were cycling through the system (IDHW-DEQ 1992). Pesticide sampling was conducted in June 2000. Results were no detectable concentrations of pesticides.

Beneficial Use Reconnaissance Project data collected in 1994 found the mainstem Pack River stream substrate to be made up of 100% fines (< 6 mm) in a reach studied near the Pack River

School. The Habitat Index developed for this reach scored a 56, which results in an Impaired rating. The Macrobiotic Index for this reach showed a score of 4.04 which resulted in a Not Impaired status for this community. This data has since been determined to be not applicable to the mainstem Pack River, since it was conducted under the Wadable Stream criteria. This segment of the Pack was determined to better fit the Large River protocol instead. In 1997 a Large River Survey was conducted 100 meters below the Colburn Rd. bridge. No support status conclusions are available from this data.

In 1997 and again in 2000 dissolved oxygen (Table 1.) and bacteria samples were taken along the lower Pack River. The presence of E. coli was tested for in five samples taken in August, 2000. All samples were below the 406 e. coli organisms/100 ml as required by the Idaho Water Quality Standards for single sampling events. Results were 3, 7, 40, 13 and 120 organisms. The July and August 1997 sampling of fecal coliform, 80/100 and 44/100 ml, were also below the previous standard for fecal coliform of 800/100 ml. Additional sampling will be conducted in 2001 to achieve the five samples per site over a thirty day time period to meet water quality standards requirements.

Table 1. Dissolved oxygen (mg/L).

Site #	Surface	One Meter	Two Meter	Three Meter	Four Meter	Bottom
1.	7.89	-	8.28	-	8.14	7.96
2.	7.96	8.00	7.95	-	-	-
3.	8.39	8.39	8.40	8.41	-	-
4.	8.27	8.20	-	-	-	-
5.	7.92	7.93	-	-	-	-

These values indicate that low dissolved oxygen is not currently impairing beneficial uses the mainstem Pack River.

In 1998, the Pack River was evaluated as part of the Cumulative Watershed Effects program developed by the Idaho Department of Lands. This program has been instated as part of the Idaho Forest Practices Act. In contrast to indirect indicator and model-based approaches, this program relies on direct observations made in the stream and on the surrounding landscape. The process consists of an assessment of fine sediment in stream bottoms, channel stability, sediment delivery, water temperature/stream shade, nutrients, and hydrology, as affected by forest practices. This evaluation produced results on forested lands near the headwaters of the Pack River as summarized below by Dechert et. al. (1999):

Category	Scores	Ratings
Channel Stability Index	52	Moderate
Canopy Removal Index	0.16	N/A
# Segments w/Low Temp	19/24	*
# Segments w/High Temp	5/24	*
Canopy Closure/Temperature Rating	*	High
Roads	29.9	Low
Skid Trail	2	Low
Mass Failure	47.2	High
Total Sediment Delivery	79.1	Moderate
Nutrient Current Condition	32	Moderate
Nutrient Hazard Rating	*	Moderate
Overall Nutrient Rating	*	Moderate
Hydrologic Risk Rating	*	Low
CWE Surface Erosion Hazard	*	Low
CWE Mass Failure Hazard Rating	*	Low

This data indicates the following results:

a) Sediment delivery from forest practices to waterways is low for the upper watershed as a whole.

b) The nutrient condition of Pack River Headwaters is moderate, so no adverse condition exists. Most indicators of nutrient impacts occur in the Pack River mainstem where land uses other than forestry predominate.

c) For the forested portions of the watershed, the hydrologic rating is low, so no hydrologic adverse condition exists.

d) It is concluded that current forest management practices as specified by the Idaho Forest Practices Act are adequate to protect water quality and beneficial uses for the forested portions of the Pack River Headwaters watershed.

In general, the Watershed Effects analysis of Pack River Headwaters concludes that forest practices have not contributed significantly to water quality problems occurring in the headwaters of the Pack River. The mainstem, of course, has many tributaries which contribute flow and pollutants, of which there may be significant contributors of sediment.

These conclusions indicate that sources of pollution impairing beneficial uses in the mainstem Pack River are occurring in places other than the Pack headwaters, such as tributary streams and land uses along the lower reaches of the Pack River. Many tributary streams have been evaluated by the Cumulative Watershed Effects program and can be reviewed individually in Appendix B.

Nutrient budgets for the Pend Oreille Lake and Pend Oreille River upstream of Albeni Falls Dam were developed for the 1989 and 1990 water years. Frenzel (Frenzel 1991b) identified and quantified nutrient inputs from point and nonpoint sources. These data were required as an input to the nutrient load/lake response model used to assess open-lake water quality.

Nutrient budgets were calculated from the hydrologic budgets and sampled nutrient concentrations. Nutrient samples from gauged streams were collected using standard U.S. Geological Survey cross-sectional and depth-integrating methods. During snowmelt runoff in May and June, samples were collected biweekly and during the rest of the year monthly in the Pack River. Total phosphorus and total nitrogen loads were estimated for all nutrient sources (Frenzel 1991b).

According to Frenzel, in 1989 the Pack River produced a total phosphorus load estimated at 20,600 kg of phosphorus (4.4 kg margin of error). This results in a percentage contribution of almost three times more phosphorus inflow to Lake Pend Oreille (6.3% of total Lake inflow) than of total hydrologic flow (2.2% of total Lake inflow). Similar results were reported in 1990 (1991 a,b).

Total nitrogen in the Pack River was estimated to be 97,800 kilograms in 1989, with a large margin of error (52,100) due to inadequacies inherent in nitrogen sampling techniques. This was determined to be approximately 2.2% of the total Pend Oreille Lake nitrogen load. Again, similar results were reported for 1990 (Frenzel 1991b).

Frenzel also developed watershed nutrient export coefficients as another way of expressing nutrient loads. This coefficient was calculated by dividing load by drainage area. Watershed export coefficients developed for the Lake Pend Oreille watersheds showed that the largest export coefficient for total phosphorus and total nitrogen in the basin were from the Pack River. From a drainage area of 56,640 hectares, a coefficient was developed that resulted in 0.364 kg/ha for total phosphorus and 1.73 kg/ha for total nitrogen in the Pack River watershed (1991a).

In 1999, the Tri-State Water Quality Council developed a voluntary nutrient target for the Clark Fork River and the Pend Oreille Lake. The targets they agreed upon were the product of all available data and a rigorous scientific evaluation by qualified scientists who had, or are currently studying this sub-basin. Their draft nutrient targets are:

*326,000 kg/yr total phosphorus allocated to the lake
*65,000 kg/yr total phosphorus allocated to Pend Oreille Lake tributaries (excluding the Clark Fork River)
*260,000 kg/yr total phosphorus allocated to the Clark Fork River

*7.8 ug/l phosphorus concentration for the open waters of Pend Oreille Lake
*15:1 trigger value of total nitrogen to total phosphorus

A nitrogen to phosphorus ratio trigger value of 15:1 or lower was established for the Clark Fork River and Pend Oreille Lake to serve as an indicator of potential changes to water quality (Watkins, 1999). Since the Clark Fork River exerts such a strong influence on Pend Oreille Lake water quality, an increase in nitrogen could have unfavorable effects in some near-shore areas. Even though the Council's nutrient target for the lake addresses only the open water area of the lake, they felt it would be remiss to allow a nutrient present in the open water to impact bays, particularly along the northern portion of the lake. The nitrogen trigger value developed by the Council is particularly useful in the evaluation of phosphorus enriched waters, where there may be ample amounts of phosphorus for plant growth but insufficient nitrogen. Using the Council's trigger value of 15:1 (N to P) as a baseline, data indicates that the 5:1 nitrogen to phosphorus ratio in the Pack River is low enough to result in significant nutrient enrichment problems due to nitrogen.

To prevent the development of biological nuisances and to control accelerated or cultural eutrophication, EPA Gold Book states that "...total phosphates as phosphorus should not exceed 50 ug/l in any stream at the point where it enters any lake or reservoir." (EPA 1986). Based upon Frenzel's work, average concentration of the Pack River was 43 ug/l. This is an indication that phosphorus as well as nitrogen are contributing to enrichment of the Pack River.

3.c. Data Gaps for Determination of Support Status

Currently, existing watershed data is only available for the upper reaches (headwaters) of the Pack River and its tributaries through the Cumulative Watershed Effects program. Little data is available concerning nutrient and sediment pollutants in the mainstem (Hwy. 95 to Pend Oreille Lake). As was mentioned, there is no guidance developed to date as to how the 1997 Large River Survey data should be interpreted for conclusions regarding beneficial use support status. The wadable stream Reconnaissance data was determined to be not applicable.

Conclusion of Problem Assessment

The mainstem Pack River has been listed as not supporting its designated beneficial uses. The information currently available suggests that nutrients and sediment are pollutants causing this impairment. It is apparent from current data that there are widespread and diverse impacts affecting this river segment and additional study is required. Pesticides and dissolved oxygen have been discovered to be within full support limits, and therefore will be de-listed for these pollutants. Pathogens will be deferred until fall 2001 so additional samples can be taken per EPA's instructions.

5. TMDL

Because nutrients are often bonded to sediment, excess sediment is often the source of nutrient pollution. This is probably true for nutrient sources in the forested portions of the Pack River watershed and a TMDL for sediment may be sufficient for both pollutants. However, due to mixed land uses and other potential sources of nutrients in the lower portion of the watershed, it would be more conservative to not assume that all nutrients are coming from sediment. A separate TMDL for nutrients will be written to insure that other sources are not missed as potential sources for reduction. The nutrient TMDL will include load limits for phosphorus as well as nitrogen. The 1989 data shows that nitrogen may be limiting during certain times of the year. This may be true also for near-shore areas of Pend Oreille Lake in the vicinity of the Pack River delta.

5.a. Numeric Targets

<u>Nutrients</u>
Frenzel sampled phosphorus and nitrogen along the Pack River in 1989 and 1990 as part of a

larger study of the Pend Oreille Lake (Frenzel 1991). This data is the only information found concerning phosphorus and nitrogen loading in the Pack. The data is as follows:

*Total phosphorus load was 20,600 kg/yr or 6% of the phosphorus load to the lake. Error of the sample was calculated to be 4.4%.

*Nitrogen load was 97,800 kg/yr or 2% of the nitrogen load to the lake. Error of this sampling was high, 51.2%, due to laboratory error.

*Flow of the Pack River was 480 cubic hectometers (1 hectometer = 1,000,000 cubic meters), which is 1.8% of the total inflow to the lake. Error of this measurement was 15%. This percent flow was calculated using the tributaries to the lake and down to the Albani Falls dam. Using a revised inflow to the lake of 24,910hm³ the flow of the Pack River becomes 1.9% of the total inflow to the lake.

*The nitrogen to phosphorus ratio of the Pack River was approximately 5:1.

Other available information that could be used to formulate a target nutrient load is as follows:

The Tri-State Council's voluntary nutrient target for the Clark Fork River and the Pend Oreille Lake have established some draft phosphorus targets for those waterbodies based upon Frenzel's work:

*326,000 kg/yr total phosphorus allocated to the lake
*65,000 kg/yr total phosphorus allocated to Pend Oreille Lake tributaries (excluding the Clark Fork River)
*260,000 kg/yr total phosphorus allocated to the Clark Fork River

*7.8 ug/l phosphorus concentration for the open waters of Pend Oreille Lake
*15:1 trigger value of total nitrogen to total phosphorus

Lacking a target nutrient concentration for the river from either literature or field data, this TMDL will utilize the Tri-State Council's draft nutrient target and allocations to calculate phosphorus load reductions for the Pack River which are protective of Pend Oreille Lake water quality. There are 328,651 kg/yr total phosphorus allocated to the lake. The Pack River is 1.9% of the inflow to the lake. By multiplying these two numbers you get a flow weighted value of the phosphorus load allocated to the Pack River which is 6,244 kg/yr. The flow calculation has an error of 15% which would reduce this target load to **5,307 kg/yr**. The Council's load allocation for the lake tributaries other than the Clark Fork River is 69,151 kg/yr. Subtracting the Pack River load allocation leaves a 62,907 kg/yr allocation to the lake from sources other than the Clark Fork and Pack Rivers.

Nitrogen load will also be calculated based upon inflow to Pend Oreille Lake. The nitrogen load entering Pend Oreille Lake from the Pack River measured by Frenzel was 97,800 kg/yr or 2.2% of the total load entering the lake. By multiplying these two numbers you get a flow weighted value of 95,648 kg/yr. Reducing this by the margin of error in sampling (52.1%) the target load becomes **45,815 kg/yr**. As better data becomes available, this target load can be further refined.

Sediment
See attached spreadsheet.

5.b. Source Analysis

Nutrients
Source of nutrient in the Pack River have been previously discussed in the problem assessment section.

Sediment
See attached spreadsheet and Appendix B.

5.c. Linkage Analysis

Nutrients
Both phosphorus and nitrogen load limits are included in this TMDL. Measurement of nutrient reductions can be done directly by measuring nitrogen and phosphorus concentrations and flow.

5.d. Allocations

Nutrients
The data set for nutrient concentrations and flows for Pack River tributaries is minimal. Most tributaries have no information on nutrients. Allocation of loads to tributaries can be done once this information is collected. Until that time, the load for the Pack River is the only allocation. There are no point source discharges in this watershed.

Sediment
See attached spreadsheet.

5.e. Monitoring Plan

Nutrients
Nutrients will be sampled as a part of DEQ's once every five year beneficial use reconnaissance monitoring. Sampling time and location should duplicate that of Frenzel's work. Results should be flow weighted to insure that values are comparable to the target values. If one sampling effort shows that loads have been reduced to the target level, then a second sampling within the next two years should verify that fact prior to de-listing. To avoid prematurely de-listing the river the two "full support" determinations should be combined with a list of nutrient reduction measures achieved in the watershed that equate to the observed reduction. This is required due to the variable nature of nutrient concentrations which are dependent, in part, on weather and precipitation runoff patterns throughout the winter and spring months.

5.c. and 5.e. Sediment Monitoring Plan and Linkage Analysis

Because Idaho's Water Quality Standard for sediment is narrative and not based upon something directly measurable in the water column, a different approach is required to achieve a satisfactory monitoring plan. An analysis of the methods available for monitoring the success of TMDLs indicates that, in this case, more than one method should be used to verify the cause of the impairment, track load reduction, and to show that the stream is moving towards full support. The sediment monitoring plan will include three parts:

1. Determination of support status using Beneficial Use Reconnaissance monitoring. If the conclusion of the survey is no impairment for two surveys taken within a five year time period then the stream can be considered restored to full support status.

2. Load reduction measures shall be tracked and quantified. For example, 1.2 miles of road obliteration near a stream, 0.5 miles of stream bank fenced, 5 acres of reforestation, etc.

3. Amount of sediment reduction achieved by implementation of load reduction measures shall be tracked on a yearly basis. For example, 1.2 miles of road obliteration will result in a 6 tons/yr reduction, 0.5 miles of stream bank fenced will result in a 3 ton/yr reduction, 5 acres of reforestation will result in a 0.7 ton/yr reduction, etc.

The reason for this three part approach is the following:

1. DEQ presently uses the Beneficial Use Reconnaissance data to indicate if the stream is biologically impaired. Often times this impairment is based upon only one Reconnaissance survey. The survey should be repeated to insure that the impairment conclusion is correct and repeated twice after implementation to determine if the (improved) support status conclusion is correct. Survey data may show an impairment in fisheries or macroinvertebrates and the cause of the impairment may point to sediment pollution. However, there is not a direct linkage between the pollutant and the impairment. Sediment could be indicated as the problem when, in fact, temperature might be the problem. The Reconnaissance data is not specific as to the cause, just that there is a problem. So using the Reconnaissance data alone to monitor the TMDL is not adequate.

2. There is great uncertainty about how much sediment actually needs to be reduced before beneficial uses are restored. These TMDLs use a very conservative approach, in that the sediment target is limited to natural background amounts. However, beneficial uses may be fully supported at some point before this target is achieved. Therefore, a measure of sediment reduction cannot be used exclusively to determine a return to full support.

3. Because TMDLs are based upon target loads measured in a mass per unit time there must be a method included to directly measure load reductions. Coefficients which estimate sedimentation rates over time based upon land use have been used to develop the existing loads. This same method can be used for land where erosion has been reduced. Road erosion rates are based upon the Cumulative

Watershed Effects road scores. These scores can be updated as road improvements are made and the corresponding load reduction calculated.

5.f. Margin of Safety

Nutrients

The margin of error is incorporated into the phosphorus and nitrogen target load calculations in section 5.a. by reducing the target load by the amount of error found in the data analysis. Adding an additional arbitrary margin of safety would only add to the error of the analysis, not aid in recovering beneficial uses. Because this is the case, the margin of safety exists additionally in the monitoring plan of this TMDL.

Sediment
Because the measure of sediment entering a stream throughout the entire watershed is a difficult and inexact science, assigning an arbitrary margin of safety would just add more error to the analysis. Instead, all assumptions made in the model have been the most conservative available. In this way, a margin of error was built into each step of the analysis. Explanations of some of the values have not been detailed as yet on the spreadsheets pending their revision. Background loading from land uses and stream bank erosion coefficients are being revised to be specific to the Pend Oreille watershed. Once the revised values are received the "Sediment Yield" portion of the spreadsheet will more fully explain the source of the values. For an explanation of how the Cumulative Watershed Effects data was collected and processed, refer to the Idaho Department of Lands manual titled, "Forest Practices Cumulative Watershed Effects Process For Idaho". One important detail to note when looking at how the Cumulative Effects data was used in the TMDL is that, although all forest roads in the watershed were not assessed, the field crews are directed to assess the roads most likely to be contributing sediment to the stream. This weighted the average road scores towards the ones most likely to be in poor condition.

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Pack River Watershed: Land Use Information

Land Use Sub-watershed	Pack headwaters	McCormick Creek	Minor Mid - Pack	Minor Lower Pack	***Explanation/Comments***
Pasture (ac)	**50**	**9**	**6,400**	**35051**	
Forest Land (ac)	**14209**	**4346**	**37338**	**18057**	
Unstocked Forest (ac)	***5156**	***2280**	**10081**	**1445**	*Includes once burned areas*
Highway (ac)	**0**	**0**	**0**	**4.5**	*State or County paved highways*
Double Fires (ac)	**1147**	**75**	**8017**	**0**	*Areas which have been burned over twice*

Road Data Sub-Watershed	Pack Headwaters	McCormick Creek	Minor Mid-Pack Tribs.	Minor Lower Pack Tribs.	
1. Forest roads (total miles)	**46**	**12**	**59**	**154**	
CWE road score (av)	29.9	28.9	##25	##23	
**Sediment export coefficient (tons/mi/yr)	**10.4**	**9.6**	**7.0**	**6.0**	
#Total Forest Rd Failures (cubic yds delivered)	**689**	**865**	**874.4**	**387.2**	*Cumulative Watershed Effects data*
###2. Unpaved Co.& priv. roads (total miles)	0	0	**8**	**103**	
Paved Co.&priv. roads (total miles)	0	0	0	19.5	
Total C&P Rd Failures (cubic yds delivered)	0	0	**118.5**	**259**	*Based on weighted average of forest road failures.*
####Stream bank erosion-both banks (mi)					****erosion coefficients*
poor condition	0	0	**2.75**	**6.25**	*95 tons/yr/mi*
good condition	0	0	**17.5**	**14**	*47.5 tons/yr/mi*

*Erosion attributed to the Sundance Fire.
**McGreer et al. 1997
***Stevenson 1999. Good condition: 5,280'/mi X 2' high bank X 90lbs/ft3 X 0.1 ft/yr X 1 ton/2000lbs = 47.5 tons/yr/mi.
Poor condition: 5,280'/mi X 2' high bank X 90lbs/ft3 X 0.2 ft/yr X 1 Ton/2000lbs = 95.0 tons/yr/mi.
#Total road failures are the amount of sediment observed by the CWE crews that was delivered to the stream. This amount is used to represent the yearly delivery to the stream. This is an over-estimate of sediment delivered to the stream since failures can continue to deliver sediment to the stream for a number of years after they occur, however, in a much reduced quantity. One must also take into consideration that all failures were not observed, which is an under-estimate of delivered sediment. Thses two factors combined with on-site verification by a

largest failures which probably occurred during the floods of 1996.
##Presumed CWE score for roads and road failures derived from a weighted average of CWE scores by geologic type from watersheds assessed by CWE in the Pend Oreille watershed.
###County and private road erosion derived from using the same method as forest roads. Since the method used for forest roads is not designed for non-forest roads, the calculations will be revised if a better method can be found using the existing information.
####Source of data from 1996 aerial photos.

Pack River Watershed: Land Use Information (cont.)

Land Use

Sub-watershed	Homestead	Jeru	Martin	Lindsey	Hellroaring	Caribou
Pasture (ac)	**0**	**0**	**0**	**3**	**5**	**19**
Forest Land (ac)	**2335**	**3556**	**2314**	**2401**	**7723**	**9154**
Unstocked Forest (ac)	***735**	***1793**	**461**	**369**	**1333**	**1081**
Highway (ac)	0	0	0	0	0	0
Double Fires (ac)	**1952.8**	**190.9**	**2212.7**	**33.1**	**137.0**	**0**

Road Data

Sub-Watershed	Homestead	Jeru	Martin	Lindsey	Hellroaring	Caribou
1. Forest roads (total miles)	**8.1**	**15.9**	**5.4**	**15.9**	**40.8**	**45**
CWE road score (av)	32.6	16.3	13	29.2	59.8	35.4
**Sediment export coefficient (tons/mi/yr)	**12.9**	**3.6**	**2.8**	**9.8**	**76.9**	**16.2**
#Total Forest Rd Failures (cubic yds delivered)	**14**	none	**27**	0	**361**	**981**
2. Unpaved Co.& priv. roads (total miles)	0	0	0	0	**1.0**	**1.5**
Paved Co.&priv. roads (total miles)	0	0	0	0	0	0
###Total Road Failures (cubic yds)	0	0	0	0	**8.8**	**32.7**
####Stream bank erosion-both banks (mi)						
poor condition	0	0	0	0	0.5	0.2
good condition	0	0	0	0	0	0.3

Pack River Watershed: Land Use Information (cont.)

Land Use

Sub-watershed	Berry	Sand	Colburn	NF Grouse	Grouse	Lwr Grouse
Pasture (ac)	**80**	**15**	**1064**	**8**	**45**	**8498**
Forest Land (ac)	**6002**	**8032**	**4453**	**9529**	**16848**	**12747**
Unstocked Forest (ac)	**2128**	**251**	**945**	**1268**	**1192**	**1020**
Highway (ac)	0	0	**23.6**	0	0	**12.1**
Double Fires (ac)	0	0	0	0	**2287.6**	**25**

Road Data

Sub-Watershed	Berry	Sand	Colburn	NF Grouse	Grouse	Lwr Grouse
1. Forest roads (total miles)	**40**	**39**	**34.5**	**55**	**41.7**	**26**
CWE road score (av)	46.7	21.9	27.8	29.6	20.9	##22
**Sediment export coefficient (tons/mi/yr)	**35.7**	**5.6**	**8.8**	**10.2**	**5.2**	**5.5**
#Total Forest rd failures (cubic yds delivered)	**755**	**113**	**477**	**628**	**57**	**200**
2. Unpaved Co.& priv. roads (total miles)	**0.4**	**4.6**	**7.5**	**5.2**	**0.5**	**6**
Paved Co.&priv. roads (total miles)	0	0	0	0	0	**3**
###Total C&P rd failures (cubic yds)	**7.6**	**13.3**	**103.7**	**59.4**	**0.7**	**46.2**
####Stream bank erosion-both banks (mi)						
poor condition	**0.2**	1.0	0	1.9	3.0	**0.2**
good condition	0	0	0	7.3	1.5	**0.5**

Pack River Watershed: Land Use Information (cont.)

Land Use			
Sub-watershed	Gold	Rapid Lightning	Trout
Pasture (ac)	**924**	**1251**	0
Forest Land (ac)	**6007**	**61288**	**13286**
Unstocked Forest (ac)	**385**	**4903**	**1063**
Highway (ac)	0	0	0
Double Fires (ac)	0	0	0

Road Data			
Sub-watershed	Gold	Rapid Lightning	Trout
1. Forest roads (total miles)	**24**	**100**	**20**
CWE road score (av)	18.3	##27	##25
*Sediment export coefficient (tons/mi/yr)	**4.2**	**8.2**	**7.0**
##Total forest rd failures (cubic yds delivered)	0	**1760**	**295**
2. Unpaved Co.& priv. rds (total miles)	9	**14**	0
Paved Co. & priv. rds (total miles)	0	0	0
###Total C&P rd failures (cubic yds)	0	**246.4**	0
####Stream bank erosion -both banks			
poor condition	**0.5**	**6**	0
good condition	**0.4**	**4**	0

Pack River Watershed: Sediment Yield

Sediment Yield From Land Use

Watershed:	Pack headwaters	McCormick	Yield Coeff. (tons/ac/yr) as shown in ( )	
Pasture (tons/yr)	7 (0.14)	1.3 (0.14)		
Forest Land (tons/yr)	539.9	165.1	*0.038*	
Unstocked Forest (tons/yr)	87.7	38.8	*0.017*	*(this acreage is a subset of Forest Land acreage)*
Highway (tons/yr)	0.0	0.0	*0.034*	
Double Fires (tons/yr)	19.5	1.3	*0.017*	*(this acreage is a subset of Forest Land acreage)*
Total Yield (tons/yr)	**654.1**	**206.5**		

Explanation/Comments
Acres by Land Use X Sediment Yield Coefficient = Tons Sediment/yr

(Values taken from WATSED and RUSLE models-see below explanation [#])

*Sediment Yield From Roads

Watershed:	Pack headwaters	McCormick	
Forest Roads (tons/yr)	**478.4**	**277.4**	*Miles Forest Rd X Sediment Yield Coeff. from McGreer Model*
Forest Road Failure (tons/yr)	**986**	**1237.8**	***Assumes soil density of 1.7 g/cc; conversion factor from cubic yds to tons = 1.431.*
County and Private Roads (tons/yr)	0	0	
Co. and Private Road Failure (tons/yr)	0	0	

*Percent fines and percent cobble-gravel average of the Pend Oreille-Priest-Prouty-Jeru-Treble series A&B soil horizons is 75% fines, 25% cobble-gravel (Bonner Co. Soil Survey).
**"Guide for Interpreting Engineering Uses of Soils" USDA, Soil Conservation Service. Nov. 1971.
#Land use sediment yield coefficients sources: pasture obtained from RUSLE with the following inputs: Erosivity based on precipitation; soil erodibility based on soils in the watershed; average slope length and steepness by watershed; plant cover of a 10 yr pasture/hay rotation with intense harvesting and grazing; and no support practices in place to minimize erosion.
Forest Land (0.038) obtained from WATSED with the following inputs: (revised watershed specific WATSED values to be provided by USFS)
Unstocked Forest (0.017) obtained from WATSED with the following inputs: Acreage of pendings, landtype and years since harvest.
Highways (0.34) obtained from WATSED with the following inputs: Value obtained from the Coeur 'd Alene Basin calculations.
Double Fires (0.017) obtained from WATSED with the following inputs: Acreage, years since fire and landtype.

Pack River Watershed: Sediment Yield

Sediment Yield From Land Use	Minor	Minor					
Watershed:	Mid-Pack Tribs.	Lwr Pack Tribs.	Homestead	Jeru	Martin	Lindsey	Hellroaring
Pasture (tons/yr)	1600 (0.25)	17175 (0.49)	0 (0.14)	0 (0.14)	0 (0.14)	0.42 (0.14)	0.7 (0.14)
Forest Land (tons/yr)	1418.8	1418.8	88.7	135.1	87.9	293.5	293.5
Unstocked Forest (tons/yr)	171.4	171.4	12.5	30.5	7.8	6.3	22.7
Highway (tons/yr)	0	0.1	0	0	0	0	0
Double Fires (tons/yr)	136.3	0	33.2	3.2	37.6	0.6	2.3
Total Yield (tons/yr)	**3326.5**	**18765.3**	**134.4**	**168.8**	**133.3**	**300.8**	**319.2**

*Sediment Yield From Roads	Minor	Minor					
Watershed:	Mid-Pack Tribs.	Lwr Pack Tribs.	Homestead	Jeru	Martin	Lindsey	Hellroaring
Forest Roads (tons/yr)	413	924	**104.5**	**57.2**	**15.1**	**155.8**	**3137.5**
Forest Road Failure (tons/yr)	1251.3	554.1	**20**	0	**38.6**	0	**516.6**
County and Private Roads (tons/yr)	56	618	0	0	0	0	**76.9**
Co. and Private Road Failure (tons/yr)	169.6	370.6	0	0	0	0	**12.6**

Pack River Watershed: Sediment Yield

Sediment Yield From Land Use

Watershed:	Caribou	Berry	Sand	Colburn	NF Grouse	Grouse
Pasture (tons/yr)	2.66 (0.14)	12 (0.15)	3.3 (0.22)	159.6 (0.15)	1.1 (0.14)	34.2 (0.76)
Forest Land (tons/yr)	347.8	228.1	305.2	169.2	362.1	640.2
Unstocked Forest (tons/yr)	18.4	36.2	4.3	16.1	21.6	20.3
Highway (tons/yr)	0	0	0	0.8	0	0
Double Fires (tons/yr)	0	0	0	0	0	38.9
Total Yield (tons/yr)	**368.9**	**276.3**	**312.8**	**345.7**	**384.8**	**733.6**

*Sediment Yield From Roads

Watershed:	Caribou	Berry	Sand	Colburn	NF Grouse	Grouse
Forest Roads (tons/yr)	**729**	**1428**	**218.4**	**303.6**	**561**	**216.8**
Forest Road Failure (tons/yr)	**1403.8**	**1080.4**	**161.7**	**682.6**	**898.7**	**81.6**
County and Private Roads (tons/yr)	**24.3**	**14.3**	**25.8**	**66**	**53**	**2.6**
Co. and Private Road Failure (tons/yr)	**46.8**	**10.9**	**19**	**148.4**	**85**	**0.7**

Pack River Watershed: Sediment Yield (continued)

Sediment Yield From Land Use

Watershed:	Lwr Grouse	Gold	Rapid Lightning	Trout
Pasture (tons/yr)	849.8 (0.10)	240.2 (0.26)	950.8 (0.76)	0 (0.76)
Forest Land (tons/yr)	484.4	228.3	2329	504.9
Unstocked Forest (tons/yr)	17.3	6.5	83.4	18.1
Highway (tons/yr)	0.4	0	0	0
Double Fires (tons/yr)	0.4	0	0	0
Total Yield (tons/yr)	**1352.3**	**502.7**	**3363.2**	**522.1**

Sediment Yield From Roads

Watershed:	Lwr Grouse	Gold	Rapid Lightning	Trout
Forest Roads (tons/yr)	**143**	**100.8**	**820**	140
				422.1
Forest Road Failure (tons/yr)	**286.2**	0	**2518.6**	422.1
County and Private Roads (tons/yr)	**33**	**37.8**	**114.8**	0
Co. and Private Road Failure (tons/yr)	**66.1**	0	**352.6**	0

Pack River Watershed: Sediment Exported To Stream

	Pack Headwaters	McCormick Creek	Minor mid-Pack Tribs.	Minor lwr-Pack Tribs.	Homestead	Jeru	Martin
Land use export (tons/yr)	654.1	206.5	3326.5	18765.3	134.4	168.8	133.3
Road export (tons/yr)	478.4	277.4	469	1542	104.5	57.2	15.1
Road failure (tons/yr)	986.0	1237.8	1420.9	924.7	20	0	38.6
Bank export (tons/yr)							
poor condition	0	0	261.3	593.8	0	0	0
good condition	0	0	831.3	665	0	0	0
Total export (tons/yr)	**2118.5**	**1721.7**	**6309**	**22490.8**	**124.5**	**226**	**187**
*Natural Background Mass Failure (tons/yr)	1069	0	312.8	173.2	0	0	0

*Background mass failure is the difference between the estimated total mass failure observed in the watershed and mass failure contributed by roads.

Pack River Watershed: Sediment Exported To River

	Lindsey	Hellroaring	Caribou	Berry	Sand	Colburn
Land use export (tons/yr)	300.8	319.2	368.9	276.3	312.8	345.7
Road export (tons/yr)	155.8	3214.4	753.3	1442.3	244.2	369.6
Road failure (tons/yr)	0	529.2	1450.6	1091.3	180.7	831
Bank export (tons/yr)						
poor condition	0	47.5	19.0	19.0	95.0	0
good condition	0	0	14.3	0	0	0
Total export (tons/yr)	**456.3**	**4110.3**	**2606.1**	**2828.9**	**832.7**	**1546.3**
Natural Background Mass Failure (tons/yr)	0	432.2	450.8	0	45.8	334.9

Pack River Watershed: Sediment Exported To River

	NF Grouse	Grouse	Lwr Grouse	Gold	Rapid Lightning	Trout	**Watershed Total**
Land use export (tons/yr)	384.8	733.6	1352.3	502.7	3363.2	522.1	32,171.3
Road export (tons/yr)	561.0	219.4	176	138.6	934.8	140	11,293.0
Road failure (tons/yr)	898.7	82.3	352.3	0	2871.2	422.1	13,337.4
Bank export (tons/yr)							
poor condition	180.5	285	19.0	47.5	570	0	4,299.1
good condition	346.8	71.3	23.8	19.0	190	0	
Total export (tons/yr)	**2371.8**	**1391.6**	**1923.4**	**707.8**	**7929.2**	**1084.2**	**Grand Total: 61,100.8**
Natural Background Mass Failure (tons/yr)	322	25.8	93	0	837.1	141.7	Background Mass Failure Total: 4,238.3 tons/yr

Pack River Watershed

	Acres	Yield Coefficient (tons/ac/yr)		Background Load (tons/yr)
Total Watershed	293,047			
Presently Forested	239,047			
Estimated Historically Forested	290,487	0.038		11,038.5
Estimated Historically Pasture	2560	0.14		358.4
Nat. Mass Failure (tons/yr)				4,238.3
Background Load = Target Load			**Target Load**	**15,635.2**
			Existing Load	**61,100.8**
			Load Reduction	**45,465.6**